Space Weather Technical Forecast

Issued on Thursday, 12 October 2023 at 13:02 Local

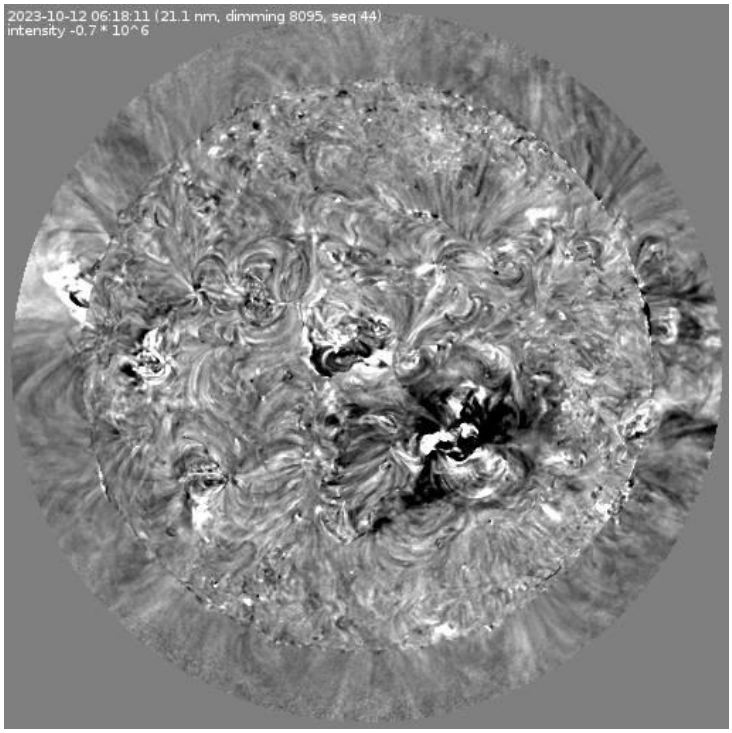
This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Ongoing Chance of M-class flares. Now reduced Slight Chance of G1/Minor Geomagnetic Storm intervals to end current UTC week. Possible new CME awaiting imagery.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity, as measured by GOES16 and 18 has risen to Moderate in the past 24 hours, with AR3451 on the northwestern limb producing a peak M1.1 flare at 12/0458UTC. This was preceded by a long-period C9.7 flare from AR3460 in the south-centre disc. The flare from AR3460 appears to have an associated CME from the concurrent dimming, although there was no imagery available to confirm this as of the issue of this document. This is a main point of monitoring in the coming hours.

Figure 0: SIDC ROB processed time-integrated AIA211 dimming in wake of C9.7 flare from AR3460. This has not yet revealed any obvious CME in coronagraph imagery.



There were up to nine sunspot regions on the facing side of the Sun in the period, with AR3466 in the central northeast attaining a number, as AR3451 became largely indistinct in the northwest. A global HMI imagery outage is hampering recent sunspot analyses, however lower resolution NSO GONG intensitygram data appears to show that the main changes include some proliferation of trailing spots in AR3463 in the southeast (a Dai/Beta), while newly-designated

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AR3466 has shown a spreading trend as a Cro/Beta. The nominally most potent sunspot groups on the Sun are AR3460, which (in the last available HMI magnetogram data) showed a possible tenuous trailing Mt Wilson Delta spot in its Dsi/BGD classification, while the peak-flare producing AR3451 is at least a Dki/BG.

There are numerous filaments on the Earth-facing disc at present, however observed Coronal Mass Ejection (CME) activity has been largely limb-ward. The main observed features on coronagraph imagery have been a large and wide CME from narrowly behind the northeast limb, (perhaps from the vicinity of Ex-AR3435); as well as a narrower and apparently slower emission from AR3454 at 11/2304UTC. Both of these CMEs have been analysed and although results are awaited, their distance from the Sun-Earth line means that effects at Earth are unlikely.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by ACE/DSCOVR, continue to show a (probable) slow regime, albeit with a weak Solar Sector Boundary Crossing (SSBC) observed at 11/1515UTC, whereupon the phi angle changed from positive to negative (the latter towards the Sun). It is remotely possible that this is the awaited fast wind from CH58, however it is extremely weak if this is the case.

The solar wind speed rose from 275 to 325km/s through the above change, with the density largely unperturbed in single figures ppcc. The IMF was mainly smooth a small-scale at or below 6nT, but with a minor discontinuity upwards associated with the SSBC. The north-south component varied between +/-4nT, being mainly near-neutrally aligned.

The net effect of the above solar wind measures was provisionally Quiet geomagnetic activity throughout, with Kp at 0 or 1.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at background levels, with no obvious minor response to any of the observed flare events of the period.

GOES16 high energy (greater than 2MeV) electron flux was at Normal Background to Moderate levels, peaking around 200pfu in the UTC afternoon of 11 October. Associated 24-hour fluence was below the Active (1e8 integrated pfu) threshold. The observation at 12/0000 UTC was 3.88e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a continuing Chance of M-class flares through the four-day period.

Solar Wind / Geomagnetic Activity: The CME associated with the C6.6 flare of AR3460 on 08 Oct is now overdue but may yet arrive at Earth in the coming 12 hours. There is now also a possible new CME from the C9.7 flare from AR3460 on 12 October, although analysis is pending imagery.

The only fast wind expected is now also overdue (from CH58/-). Given the late onset(s) of the CME and fast wind, the relative risk of G1 is now lowered and curtailed to within the current UTC working week, else falling Quiet into the UTC weekend.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux will most likely remain at Background levels.

High energy electron flux (greater than 2MeV) is forecast to continue at current levels, with the late CME and fast wind arrival now likely delaying and damping any rise towards 24-hour Active electron fluence, with a Slight Chance from the UTC weekend.

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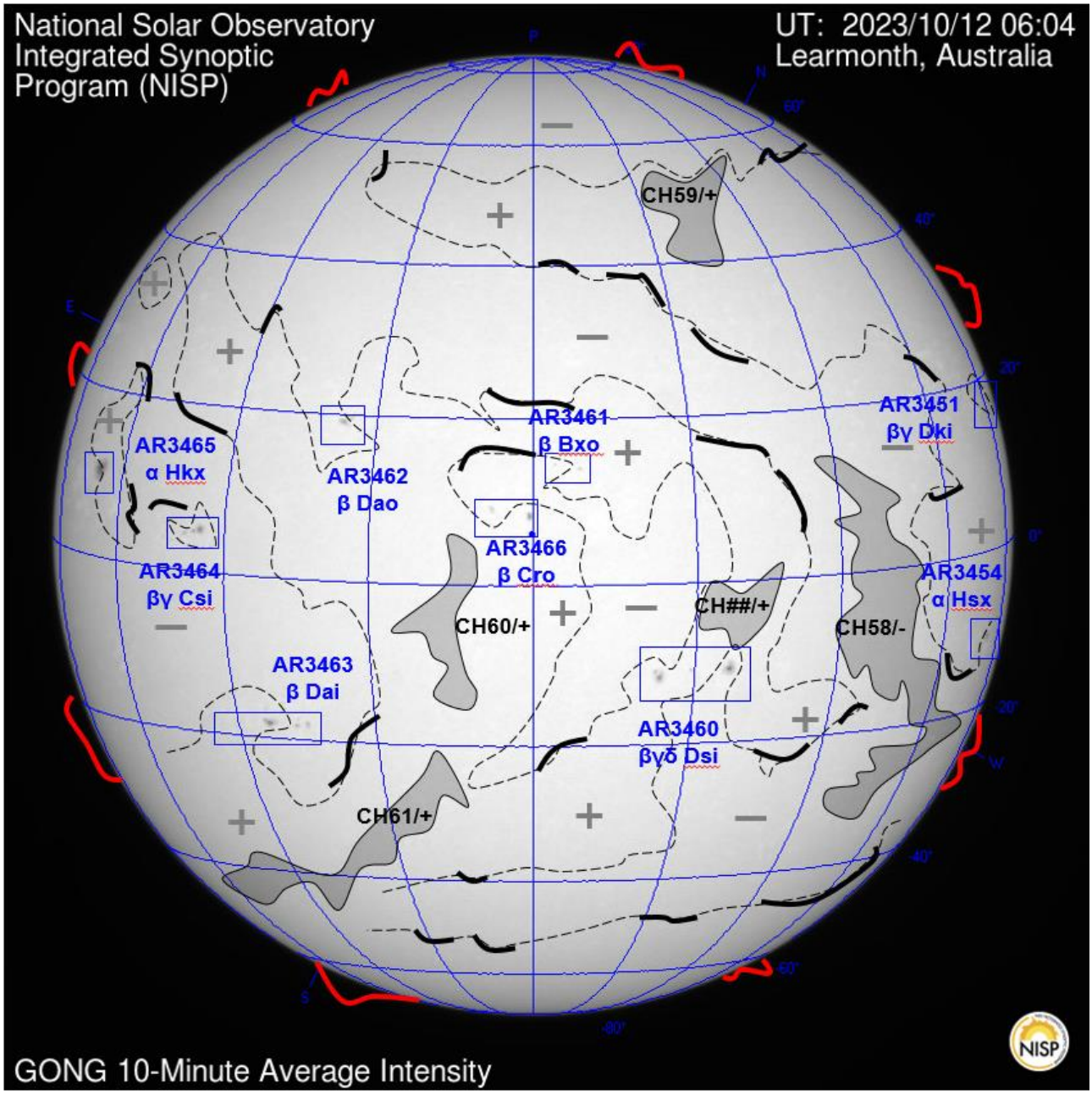
Figure 1. Solar Analysis Valid 12/0605UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is currently one overdue CME in the forecast - that associated with the C6.6 flare of AR3460 that left the Sun on 08/0339 UTC. There is now also a probable CME from the C9.7 flare from AR3460, although imagery confirming this is awaited and it does not therefore feature in the forecast.

Solar wind conditions at Earth currently suggest the continuance of a slow regime, with the phi angle now correct for the anticipated CH58/-, although the SSBC at 11/1515UTC does not strongly imply any following fast wind. ACE EPAM LEMS evidence is also lacking - either for any impending CME, else fast wind. Earth's avoiding this feature is considered very unlikely given its position on the disc (it being trans-equatorial), so the only logical deduction is that it has a slower than anticipated emanating 'fast' wind - perhaps 425km/s at worst given its leading edge position (55 West) and assuming imminent arrival.

Note that a minor positive polarity coronal hole in the wake of this larger feature was not present on the disc until recent hours, and any emanating fast wind will only cross 1AU after Earth has moved ahead of its trajectory. note also that the likely more potent coronal hole(s) CH60 and perhaps CH61 are not likely to affect Earth in the period, perhaps instead becoming relevant into the new UTC working week.

Given that both the CME and perhaps also the fast wind from CH58/- are now on the long end of arrival estimates, their likely effects have been reduced, with a tail of risk seeing out the current UTC working week before falling mainly Quiet into the UTC weekend.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	10	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
08/1435	Partial	AR3460	SE	460km/s	Imminent or miss	May have now passed 1AU to no effect

Figure 2: AIA 211 imagery from three days ago and the current UTC day, showing a newly-emerged minor coronal hole (boxed red) that is perhaps related to the dimming from the C9.7 flare from AR3460. This feature is now pparently closing and any emanating fast wind is not likely to affect

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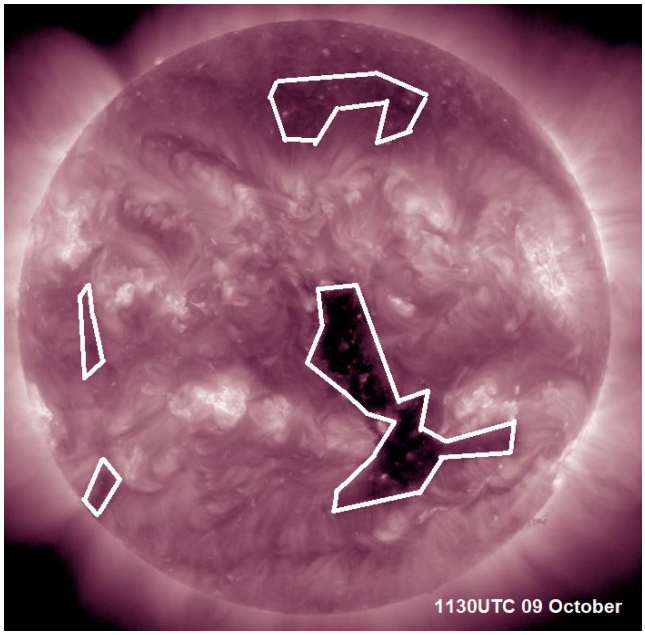
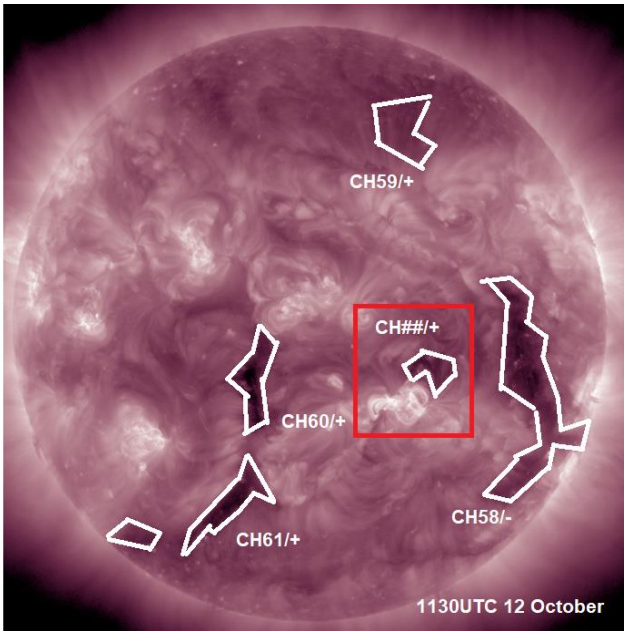
Earth. Any CME is as yet unaccounted for. Note the likely difficulty in avoiding the large and (visually) intense footprint from CH58/-/





Radio Blackouts - X-Ray Flares:

There are currently up to nine sunspots on the visible disc, although proper analysis of their behaviour is more limited than typical given a lack of recent HMI imagery.

The population of front-sided groups is more likely to rise than fall in the coming few days, with recent narrowly far-sided northeast limb CME evidence suggesting a possible survival of a at least one region here, perhaps Ex-AR3435. This forms part of a potentially large cluster of regions that also appear on far-side soundings that are expected to progressively arrive over the eastern limb into the UTC weekend.

The degree to which these regions may compensate for the more limited western solar horizon losses in the period is open to question, but given the weight of numbers and the CME, it is perhaps more likely now that any improvement in the flare risk from AR3451 leaving is blunted by these arrivals. All considered, a M-class flares are now held at a constant Chance throughout.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	50	50
Very Active	R3 to R5 X Class	No	5	5	5	5

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Figure 3: SIDC ROB visualisation of C-class flares and above (PROBA2) over the past 24 hours to 12/1230UTC, showing a relatively well-spread distribution of activity, although this belies the somehwat larger magnitude contirbutions of AR3460 and AR3451.

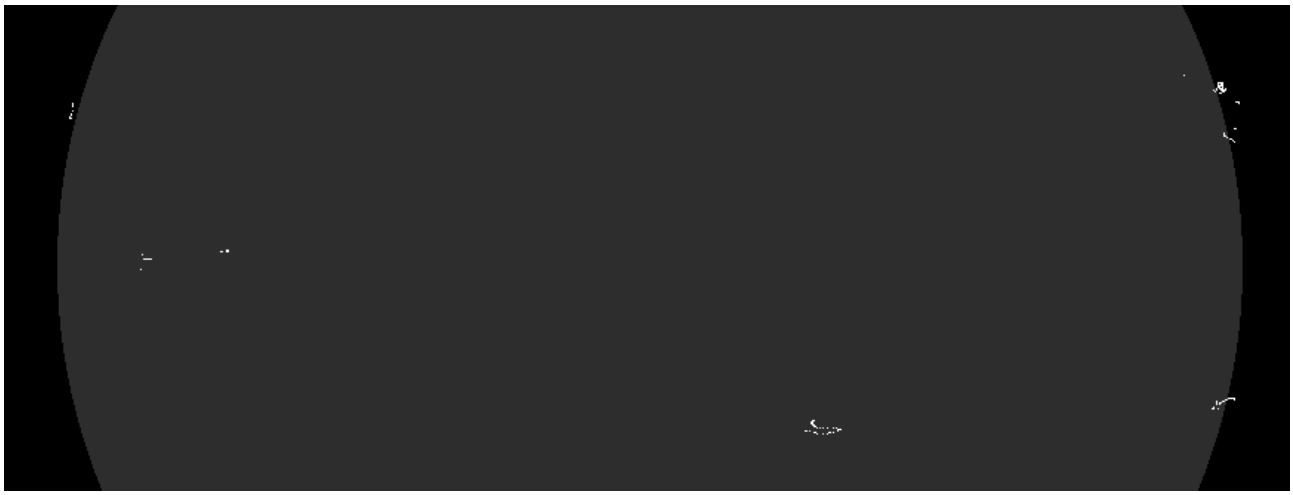
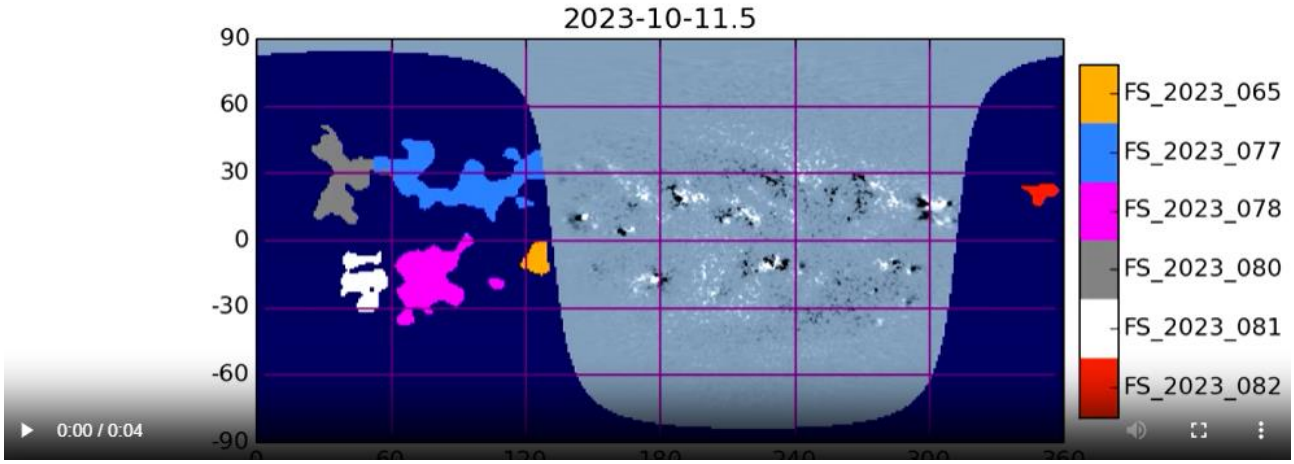


Figure 4: Far side sounding and front side HMIB imagery showing possible returning regions as of 12UTC 11 October (mid-blue and orange areas on left of plot).



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is most likely to persist at Background levels, with not even a minor enhancment seen in the wake of the recent M1.1 west limb flare from AR3451.

There remains a Slight Chance of S1/Minor Solar Radiation Storms throughout the period, should any suitable larger flares occur.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES16 has likely reached a steady state in peaking at Moderate levels at the diurnal maximum in recent days. The expected drivers of any increase to this are now overdue or else perhaps very underwhelming (depending on the origins of the 11/1515UTC SSBC), and will likely result in a delay and dampening of any rise, probably not starting until the coming UTC weekend.

The C9.7 flare and possible CME remains a main point of monitoring, but in the absence of any influence from this, a Slight Chance of Active 24-hour integrated fluence is suggested for the UTC weekend, perhaps interrupted should any CME arrive. Persistence forecasting is felt to offer a better steer than the latest MOSWOC REFM - while both know nothing of upcoming CMEs, persistence fluence levels are nearer current observations.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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